Food and Agriculture Organization of the United Nations

Poultry and pig nutrition

A guide to Pacific Island countries

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Abbreviations

ANF	antinutritional factor
CPM	cassava peel meal
DE	Digestible energy
DM	dry matter
FAO	Food and Agriculture Organization of the United Nations
FCR	feed conversion ratio
GE	gross energy
HCN	Hydrocyanic Acid
INRA	Institute National de la Recherche Agronomique
MBM	Meat and bone meal
ME	Metabolizable energy
NDF	neutral detergent fibre
PICs	Pacific Island countries
USP	the University of the South Pacific

1. Introduction

Pigs and poultry are the fastest growing livestock industries globally (FAO, 2021). They are the most important species in the Pacific Island countries (PICs), providing animal protein security and rural income. Pigs and poultry are monogastric animals that often compete with humans over already scarce feed ingredients, such as cereal grains. High feed cost is a major constraint to efficient pig and poultry production on a commercial scale in PICs due to the unavailability of traditional ingredients in the region. Available alternative or non-traditional ingredients are bulky, highly variable in nutrient content and may contain several antinutritional factors (ANFs) that limit their efficient use in pig and poultry diets. With appropriate processing and correct feed formulation, these ingredients could be included in diets to maintain productivity and reduce costs on smallholder pig and poultry farms. This manual will equip livestock extension staff and farmers with knowledge to maximize the utilization of low-cost ingredients for efficient pig and poultry production in the region. There is, however, an additional need for face-to-face trainings on feed processing and diet formulation.

2. Pigs and poultry feeding habits

Sustainable pig and poultry feeding requires knowledge of their feeding habits and feed utilization patterns. Pigs and poultry are monogastric animals (they have one stomach compartment), omnivores (they feed on plant and animal products) and have similar digestive systems. They compete with humans for food, which makes feeding them more expensive. In both species, feed digestion (breakdown) starts in the stomach and most of the feed nutrients are absorbed in the small intestine. Their digestive system produces limited endogenous enzymes, which reduces their ability to breakdown fibre. Feed particles that escape digestion in the stomach and small intestine are fermented in the large intestine (mainly in the caecum). Nutrients released from fermentation in the large intestine are of little nutritional benefit to pigs and poultry and high dietary fibre may increase faecal bulk and encourage wet litter. Caecal fermentation of fibre may, however, improve poultry and pig gastro-intestinal health and nutrient utilization (Lindberg 2014; Jha and Mishra 2021).

3. Nutrient sources for pig and poultry

Pigs and poultry require the same basic nutrients (water, carbohydrates, proteins, fat, vitamins, and minerals) as other animals.

Water: The most important nutrient. Lack of water reduces feed intake, affects many body functions, and slows growth. Provide *ad-libitum* only water that is fit for human consumption.

Carbohydrates: The main source of energy for pigs and poultry. They are mainly supplied from cereal grains (maize, wheat, barley, oat, sorghum) and by-products, fruits and by-products, and roots/tubers and their by-products.

Fats: Vegetable oils, animal fat and restaurant grease contain more energy than carbohydrates. Fat addition to the diet increases weight gain to feed conversion ratio. Too much fat may affect digestion of other feed components and cause health problems.

Protein: Provides amino acids that are required by pigs and poultry. Common feeds from animal sources (meat, fish, insects, etc.) and plant sources (oil seeds, pods and leaves) supply adequate amounts of protein. In pig and poultry, protein quality (in terms of amino acid composition) is more important than quantity.

Minerals: Many mineral elements (calcium, phosphorus, sodium, chloride, zinc, copper, iron, manganese, iodine, and selenium) support normal animal functions and productivity. Diets are often supplemented with minerals, but their excess can cause toxicity in the animal.

Vitamins: Most common feedstuffs supply vitamins. The animal body also produces vitamins. Diets can be supplemented with other vitamins.

The availability of selected ingredients for pig and poultry feeding in the region is summarized in Tables 3.1 and 3.2.

Table 3.1	Selected alternative energy sources for pig and poultry feeding in the Pacific	
Ingredients	**Availability**	**Comments**
Cereal by-products		
Rice bran	Readily available and cheap in rice producing countries such as Fiji and PNG.	Can be used to reduce feed cost. High fibre, phytic acid content, possible rancidity.
Wheat bran	Available and cheap from the flour industries in Fiji.	High in fibre content but should be used at moderate levels to reduce feed cost
Roots and by-products		
Cassava root	Widely grown in the region, well adapted and easy to grow.	Excellent source of energy, but low in protein, presence of cyanogenic glucosides (mainly HCN). Powder texture reduces intake.
Cassava peel	Readily available in cassava producing countries, and no competition for food.	High fibre and low energy, HCN content, powdery texture. Energy level can be boosted by addition of fat sources.
Sweet potato tuber	Grown in the region and may be available for livestock feed.	Good energy source, but powdery texture may limit intake.
Sweet potato peel	Readily available where potato is grown. No food-feed competition.	High fibre, low energy, powdery texture. Energy level can be boosted by addition of fat sources.
Yam peel	Readily available where yam is grown. No food-feed competition.	High fibre, low energy, powdery texture. Energy level can be boosted by addition of fat sources.
Taro	Most common crop in the region grown for food. Taro corm or processing wastes may be available for feed.	Poor palatability, high calcium oxalate, requires processing.
Fruits and by-products		
Banana meal	Readily available in the region.	High tannins in the peel reduces palatability. Peeling improves the feeding value.
Jackfruit meal	Readily available in the region.	May contain antinutritional factors such lecithin. Requires processing.
Breadfruit	Readily available in the region.	Good energy source for pig and poultry.

Source: Author's analysis

Table 3.1 (Cont)

Ingredients	Availability	Comments
Mango seed kernel	Mango is widely grown in the region for the pulp. Currently, the seed has limited food or industrial uses in the region.	Good energy source, high starch digestibility. Needs processing to reduce tannin content.
Papaya fruit	Readily available in the region. In countries where papaya juice is extracted, the pomace is used after juice extraction	High in nutrients and possesses functional properties but may contain several ANFs depending on the cultivar and the stage of maturity.
Avocado fruit and waste	Readily available in the region.	The fruit or waste after oil extraction is high in energy due to the residual oil.
Pandanus	Grows well on low islands and atolls of Polynesia and Micronesia.	Some species have edible, nutritious fruit and leaves. In countries where pandanus grows well, there is need for more research in its maximum utilisation for pig and poultry feeding.
Others		
Brewers' spent grain	Readily available and cheap from breweries	Average energy and protein contents. Needs to be well dried and stored appropriately to prevent mould development.
Molasses	Readily available from the sugar companies in Fiji.	Average energy content. Can be used to improve palatability and reduce dustiness from powdery feeds. High inclusion increases urine output and leads to wet litter in the house.
Animal fat	Readily available from abattoirs	Concentrated source of energy that can be used in combination with fibrous ingredients to boost the energy content of diets. Young pigs and poultry cannot digest high fat-based diets due to their small liver capacity; thus, fat level should be limited in their diets.

Source: Author's analysis

Table 3.2	Selected available protein sources for pig and poultry feeding in the Pacific	
Ingredients	**Availability**	**Comments**
Oilseeds and pulses		
Palm kernel meal	Readily available from palm oil companies in the Solomon Islands and PNG.	High fibre, gritty texture, low palatability, amino acid imbalance.
Copra meal	Available from coconut oil companies in the region.	High fibre, amino acid imbalance, and mycotoxins limit its inclusion in the diet, especially in young animals.
Pigeon peas	Grown in some countries of the region, and readily available for livestock feeding.	Good source of protein but may contain ANFs. Adequately processed meal can be included to reduce the quantity of expensive protein sources.
Leaf meals		
Cassava leaf meal	A readily available by-product of cassava harvest. No competition for food, feed and industrial uses.	Good source of protein and essential amino acids but high in fibre and HCN content that limits its feeding value. Adequately processed meal can be included to reduce the quantity of expensive protein sources.
Alfalfa leaf meal	Widely grown in the tropics for livestock feeding due to its exceptional adaptation and high forage yield.	Good protein and amino acid profile but high in fibre. Low digestibility of mature leaves.
Mulberry leaf meal	Very high leaf biomass, mainly grown for feed, sericulture and landscaping.	Good protein and essential amino acid profile, no ANFs identified in the leaves. High fibre is the major constraint.
Moringa leaf meal	Fast-growing and drought resistant tree with high leaf biomass readily available for food and feed.	Good source of protein, but high in fibre and ANFs including oxalate, tannins, saponins, trypsin inhibitor.

Source: Author's analysis

Table 3.2 (Cont)

Ingredients	Availability	Comments
Taro leaf meal	A major by-product of taro harvest, readily available in the region.	Good source of protein but fibre and ANFs, mainly oxalate, contents are limiting factors to its efficient use as feed. Adequately processed leaves can be included in the feed.
Sweet potato vines meal	Major by-product of sweet potato harvest, readily available for pig and poultry feeding.	Moderate source of protein but high fibre content reduces its feed value for monogastrics.
Leucaena leaf meal	Fast-growing perennial leguminous tree, readily available throughout the tropics.	Most palatable tropical fodder, rich in protein and carotenoids. Major constraints include antinutritional factors (tannins and mimosine) and fibre content.
Ofenga (*Pseuderanthemum whartonianum*)	Widely grown in many Pacific Island countries as a hedge. Very well adapted to atoll soils.	Leaves are high in nutrients, especially minerals and vitamins, which can be eaten fresh or cooked.
Sickle seed (*Senna obtusifolia*)	Readily available and invasive in most countries.	Leaves and seeds are good protein sources with high amino acid quality. The presence of several ANFs hinder their efficient use. Adequate processing improves the feed value for monogastrics.
Animal protein sources		
Invasive tilapia species	Many tilapia species are invasive in some countries. They can be dried and used for pig and poultry feeding. They can also be bred under a controlled environment to ensure sustainability.	Excellent source of protein and amino acids. Reduce fish meal in diets for finishing pigs, meat birds and laying hens to avoid fishy products.
Meat and bone meal (MBM)	Readily available from abattoirs (Fiji, Vanuatu, PNG et.).	High in quality protein and minerals, mainly calcium. Monitor for rancidity and observe restrictions on the inclusion of MBM in the feed.

Source: Author's analysis

Table 3.2 (Cont)

Ingredients	Availability	Comments
Blood meal	Readily available from abattoirs.	High protein content and excellent amino acid profile, but poor palatability reduces its feeding value. Palatability can be improved by mixing with other ingredients.
Poultry by-product meal	A by-product from the poultry slaughter plants. Readily available where poultry slaughter is centralized.	Similar value to meat and bone meal. It can easily go rancid. Check for safety of the product.
Rumen content meal	An important by-product of ruminant slaughter, especially cattle, which poses environmental concerns in most abattoirs.	Average protein source, high in vitamins, especially B vitamins but also high in fibre content. Can be harnessed to reduce feed cost and disposal problems.
Insects, fly larvae, snails	Some insects and snails can be major pests. Fly larvae are easy to grow.	Excellent protein sources. There is currently no commercial-scale production in the region. However, they can be reared on various readily available waste products and used as a cost-effective alternative to conventional protein sources on small and medium-scale farms.

Source: Author's analysis

4. Common nutritional terminology

Balanced ration – Supplies the right amounts and proportions of nutrients needed to maintain a healthy life and productivity.

Basic nutrients – Substances required to keep the animal healthy. These are carbohydrates, fats, protein, vitamins, and minerals.

Essential nutrients – Nutrients that need to be supplied in the feed for proper animal functioning and productivity.

Nutrient availability – The amount of feed nutrients that can be digested and absorbed by the animal. Several factors, including ingredient source, diet composition, animal species, age and productive function (physiological state), affect nutrient availability.

Physiological state – The condition of an animal's body in relation to its current function or stage, such as growing, pregnant, lactating, laying, or in maintenance. The physiological state influences the animal's nutritional and management needs.

Crude fibre – The fraction of the feed that is resistant to breakdown by digestive enzymes. Fibre should be limited in pig and poultry diets because digestion in these species is mainly enzymatic. The ability of pigs and poultry to utilise dietary fibre, however, increases with the age.

Compound feed – A nutritionally adequate feed fed as a whole ration that can support life and production without any additional substances other than water.

Concentrate – A feed used to improve the nutritional balance of the whole ration. For example, commercial protein concentrates that can be used in combination with carbohydrate sources to provide a balance of protein and energy.

Antinutritional factors – Biological compounds in the feed that can reduce nutrient utilization and animal performance. Examples are the trypsin inhibitor in soybean, oxalate in giant taro and hydrocyanic acid in cassava.

Feed additives – Products added to feed, generally in small quantities, to improve animal performance, utilization efficiency and animal product quality. Examples include prebiotics, probiotics, and enzymes.

5. Feed intake of pig and poultry

Feed intake is the amount of feed an animal eats when it has free access to feed. It is usually estimated by measuring how much feed disappears from the feeder — that is, the difference between the amount of feed given and the amount left over.

Knowledge of feed intake is essential for assessing animal performance.

- Feed intake estimates help a farmer purchase the correct quantity of ingredients to ensure a year-round supply of fresh feed with minimum price fluctuation.
- Farmers that buy compound feed from overseas can estimate the quantity of feed for each production phase to guarantee feed availability and avoid storing feed too long as its quality deteriorates in storage.
- A sudden drop in feed intake will reduce animal productivity and product quality.
- Excessive feed consumption increases production cost, and affects the performance of some classes of animals, for example, being overweight may suppress laying hen egg production and sow farrowing.

It is important to note that animal, dietary and environmental factors affect the feed intake of pigs and poultry. Tables 5.1 to 5.3 summarize pig and poultry feed intake.

Table 5.1 Average feed intake of growing pigs as percentage of body weight

Body weight (kg)	Phase and feed type	Daily feed intake (% body weight)
5–20	Weaner	6
21–49	Grower	5.4
50–100	Finisher	4

Source: Author's analysis

Table 5.2 Average feed intake and body weight changes of broilers (three growth phases)

Age (week)	Phase and feed type	Average feed intake (g/bird)	Average body weight (g/bird)
1	Starter	21	177
2		45	459
3	Grower	88	891
4		130	1 436
5	Finisher	179	2 067
6		206	2 732

Source: Author's adaptation from Cobb500 Broiler (2022)

Table 5.3	Average feed intake and body weight changes of egg-type birds (three growth phases)		
Age (weeks)	**Phase and feed type**	**Average feed intake (g/bird)**	**Average body weight (g/bird)**
1–6	Chick starter	26	450
7–18	Pullet grower	66	1 450–1 500
19 – 82	Layer	114–116	1 960

Source: Author's adaptation from Shaver 579 Layer Management Guide (2005)

Unlike in broilers, weight gain in layers should be monitored as heavier birds are not good layers. On a good feeding programme, a brown egg-type pullet will weigh 1,500 g at point of lay (about 19 weeks). From the above Tables, a farmer can estimate feed quantity for different classes of pigs and poultry for a given period to ensure continued feed supply. The exercises below are sample calculations of feed requirements for pigs and poultry farms.

Exercises on feed intake calculations

Exercise 1

Consider a pig farm with 60 weaners weighing on average 18 kg each, 50 growers weighing 40 kg each and 40 finishing pigs weighing 80 kg each.

1. How many bags (25 kg) of feed will be required for each class of pig for one month (30 days)?
2. How many bags of feed will be required on the farm for one month?
3. If the weaner feed cost USD35.00/bag, grower USD32.00 and finisher USD30.00, how much will the farm spend on feeding per month?

Answer

1.

- From Table 4.1, the feed intake of weaner pigs is 6% of body weight. Therefore, 60 weaners will consume 60 × 18 kg × 6/100 = 64.8 kg per day or 64.8 kg × 30 days = 1 944 kg. If a bag of feed weighs 25 kg, then 1 944 kg ÷ 25 kg = 77.7 bags of feed per month.
- Feed intake of 50 growers: 50 × 40 kg × 5.4/100 × 30 days = 3 240 kg or 129.6 bags of feed per month.

- Feed intake of 40 finishing pigs: 40 × 80 kg × 4/100 × 30 days = 3 840 kg or 153.6 bags of feed per month.

2. Total number of bags of feed per month = 77.7 + 129.6 + 153.6 = 360.9 or 361 bags.
3. Feed cost:

- Weaner feed = USD 35.00 × 77.7 bags = USD 2 719.50
- Grower feed = USD 32.00 × 129.6 bags = USD 4 147.20
- Finisher feed = USD 30.00 × 153.6 bags = USD 4 608.00
- Total spending on feed = USD 2 719.50 + USD 4 147.20 + USD 4 608.00 = USD **11 474.70**

Exercise 2

1. A potential egg producer wants to budget feed for 20,000 birds from day-old to culling at 82 weeks. From the feed intake table of egg-type birds, calculate the quantity of feed (bags) for each phase of production (starter, grower, and layer).
2. Given the price of the feed (WST$/ton) as: starter (2 040.00), grower (1 900.00), and layer (2,000.00), how much will the farmer spend on feed alone?

Answer

1.

- Chick starter feed – for 6 weeks or 42 days = 26 g × 20 000 chicks × 42 days = 21 840 kg or 873.6 bags.
- Grower feed – for 12 weeks or 84 days = 66 g × 20 000 birds × 84 days = 110 880 kg or 4 435.2 bags.
- Layer feed – for 64 weeks or 448 days = 115 g (mean of 114 and 116) × 20 000 birds × 448 days = 1 030 400 kg or 41 216 bags.

2. Feed cost – convert the quantity of feed from kg to ton by dividing by 1 000.

- Cost of starter feed – 21.84 tonnes × 2 040.00 = WST 44 553.60
- Cost of grower feed – 110.9 tonnes × 1 900.00 = WST 210 710.00
- Cost of layer feed – 1 030.4 tonnes × 2 000.00 = WST 2 060 800.00

Total feed cost = WST 44 553.60 + WST 210 710.00 + WST 2 060 800.00 = **WST 2 316 063.60**

5.1 Animal factors affecting feed intake

Several animal factors affect feed intake in pigs and poultry. These include the age of the animal, breed, body weight, physiological state, sex, stocking density, etc.

5.1.1 Age and breed

Feed intake increases with age and can vary in different breeds. Older animals consume more feed that younger ones. Exotic breeds consume more feed than local breeds. In poultry, broilers consume more feed than layers. Even in layers, breeds laying brown eggs consume slightly more feed than those laying white eggs.

5.1.2 Level of production

High producing animals consume more feed than average. A sow raising 10 piglets will have to produce more milk and therefore require more feed than another sow raising 6 piglets. The more eggs a hen lays, the more feed she will consume. Fast growing pigs and poultry require more feed than slow growing ones.

5.1.3 Flock size, feeding space, and stocking density

Feed intake is reported to be lower in larger bird flocks compared to smaller ones. The effect of flock size on feed intake may be due to improved feed management that results in minimal wastage on larger flocks. Several studies have reported reduced growth rate in pigs stocked at high densities due to lower feed intake. Feed intake always decreases when growing-finishing pigs are given less than optimal space per animal (Brumm *et al.* 2001). These authors observed reduced feed intake of growing pigs at high stocking density and attributed this to space restrictions. Space availability also affects feed intake. Inadequate feeder space can lead to wastage through fighting. Even with sufficient feeding space, broilers stocked at 30–40 kg/m^2 had lower feed intake compared to those stocked at 24 kg/m^2 (Poultry World, undated). According to Kornegay *et al*. (1993), the effect of stocking density on feed intake is generally related to environmental stress such as increased heat stress, ammonia build-up and pathogens.

5.2 Dietary factors affecting feed intake

Many dietary factors, that include diet composition and type of feed, affect feed intake of pigs and poultry.

5.2.1 Diet composition

Pigs and poultry have daily nutrient requirements that must be met. Deficiency in one or more essential nutrients depresses feed intake. In cases of slight nutrient deficiency, animals may increase their feed intake to meet their requirements. Energy intake is the most important factor regulating feed intake in pigs and poultry.

- Pigs and poultry will consume more feed on low energy diets and eat less when the energy concentration increases.
- Pigs and poultry may reduce their intake in diets that contain unpalatable ingredients. Some common alternative ingredients may contain cyanide, tannins, oxalates, etc.
- Dietary protein concentration also affects feed intake. Due to the high heat increment of proteins, pigs and poultry tend to consume less feed on high protein diets to reduce body heat production, especially in the tropics, where environmental temperature is often above the comfort zone.

5.2.2 Feed form

Feed physical form is an important factor in pig and poultry intake. Feeds commonly take the form of mash, pellet and crumble. Mash is a complete feed prepared by mixing finely ground raw materials to ensure uniformity and prevent animals from selecting only certain ingredients. Mash is the simplest form of pig and poultry feeds. Pellets are produced by converting finely ground mash into capsule-like (pellet) form. Pelleting is the process of mechanically pressing mash feed through a die under heat and moisture to form these pellets. Crumble feed is prepared the same way as pellet and crushed to reduce particle size. Crumble feed is most suitable for feeding starter birds. Feeding crumble or pellet increases feed intake and performance of broilers as compared to mash (Choi *et al*., 1986; Nir *et al*., 1994). The higher intake of pellet or crumble compared to mash is mainly due to i) destruction of heat-labile antinutritional factors during processing, and ii) reduced ingestion heat associated with pelleted feed. Pellets are the best form of food for feeding during high temperatures.

Mash, crumble and pellets of different sizes - ©Eastwood

5.2.3 Diet change

Pigs and poultry are fed in different phases, with each having its own specific diet. Care should be taken with diet in each phase as sudden change will take the animals aback and reduce feed intake and growth performance. Response to change of feed seems to be more pronounced in pigs than poultry. Introducing new feed should be done gradually by mixing the new and old feed and increasing the quantity of new feed daily until the digestive system adapts well to the new feed, normally within one week.

Exercise on diet change programme in pigs

Assume a farmer wants to change the diet of weaner pigs (consuming 0.5 kg feed/day) to grower feed. If there are 10 weaner pigs on the farm, they will consume 5 kg (0.5 kg × 10 piglets) of feed per day. The farmer can mix weaner and grower feeds as shown below.

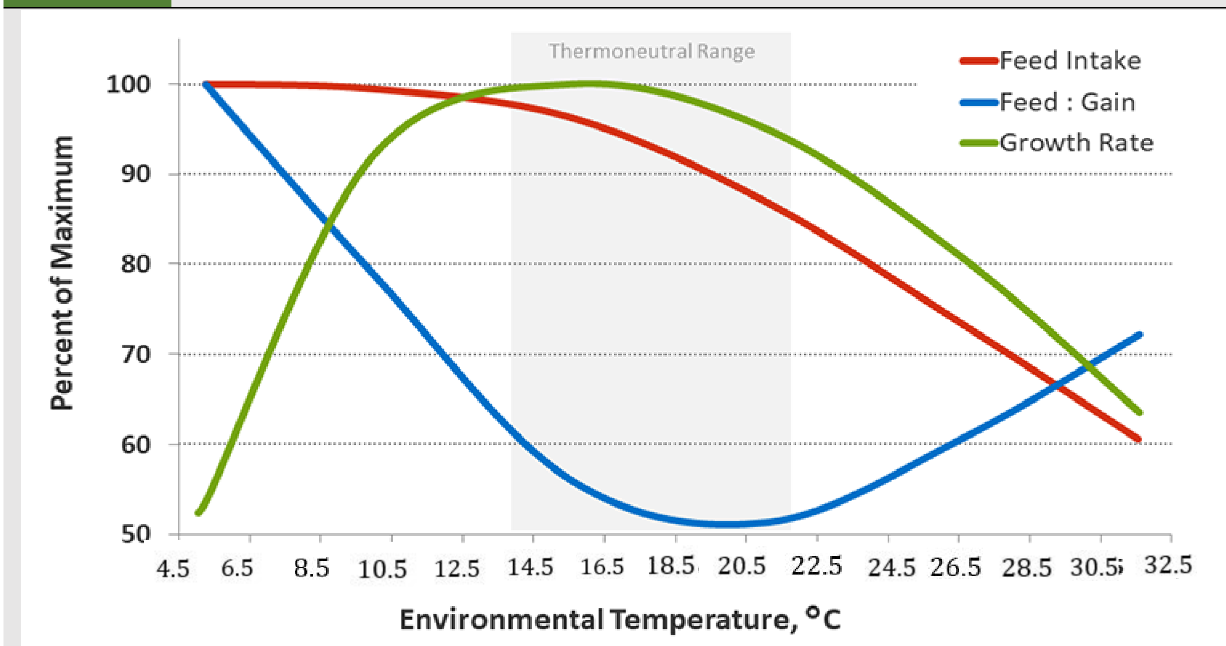
Day 1: mix 4 kg of weaner feed + 1 kg of grower feed
Day 2: mix 4 kg of weaner feed + 1 kg of grower feed
Day 3: mix 3 kg of weaner feed + 2 kg of grower feed
Day 4: mix 3 kg of weaner feed + 2 kg of grower feed
Day 5: mix 2 kg of weaner feed + 3 kg of grower feed
Day 6: mix 1 kg of weaner feed + 4 kg of grower feed
From day 7: feed whole grower feed until it is changed to finisher feed. Changing from grower to finisher should follow the same steps.

5.3 Environmental factors affecting feed intake

5.3.1 Environmental temperature

Consistent exposure of pigs and poultry to environmental temperatures below and above their comfort zone will affect feed intake. Pigs and poultry will reduce feed intake at high temperatures as to reduce body heat production from digestive processes. At lower temperatures, pigs and poultry will consume more feed, with little or no increase in weight gain, because most of the feed energy consumed is used to warm the body. This results in poorer feed conversion ratio. Oliveira and Donzele (1999) observed an 8.3 percent reduction in feed intake of gilts at 32°C compared to those kept at 28°C.

Figure 5.1 **Effect of environmental temperature on pig feed intake, weight gain and feed conversion ratio**



Source: Coffey, MT., Seereley, RW., Funderburke, DW. & Campbell, HC (1982)

Several feeding techniques can be used to stimulate feed intake of pigs and poultry at high temperatures. Commonly used techniques include the following.

- Feed during cooler periods of the day (early morning and late evening).
- When available, pellets are suitable under high temperatures. Birds consuming pellets produce less ingestion heat compared to mash.
- Diets with higher nutrient density will help pigs and poultry meet their requirements without consuming excessive feed.

- Oils are concentrated forms of energy with less heat increments. More oil in the diet as an energy source will encourage the animal to eat more and produce less digestion heat compared to carbohydrates and proteins. However, young animals have limited ability to digest fat due to their small liver capacity.
- Wet feeding (adding water to the feed), is a common practice during heat stress, but should be done with care to avoid the feed going sour. Any uneaten feed after six hours should be removed.
- Add flavourings to increase palatability.
- Animals under heat stress lose a lot of electrolytes in the sweat. Electrolyte supplementation in feed or water will minimise this effect.
- Animals should have as much access to cool water as necessary.

5.3.2 Lighting (photoperiod)

Lighting programmes affect feed intake more in poultry because birds cannot see in the dark. It is a common practice to provide continuous light during the first days of life to allow chicks to adjust to their environment. Continuous lighting in older birds may, however, encourage more activity and increase metabolic rate, and in turn wastage of feed energy as heat. Photoperiod (lighting duration) has been shown to significantly affect poultry feed intake and weight gain. Schwean-Lardner and Classen (2010), observed a significant reduction in broiler feed intake below and above 20 hours of light. Weight gain followed the same pattern. Weight gain reduction above 20 hours of light is age dependent (Figure 5.3). This may be due to the ability of broilers to adjust their feed intake to compensate for a shorter lighting period.

Birds exposed to white light tend to increase their feed intake because they can better distinguish differences in feed texture. The effect of light colour on feed intake is mostly related to factors such as light intensity and feed colour. Provision of intense blue or green light, or red-coloured feed under blue or green light, has been shown to increase feed intake. These effects are mainly due to behavioural changes: blue or green light calms chickens, while red light reduces feather pecking and cannibalism (Olanrewaju *et al*. 2006; Senaratna *et al*. 2015; Khaliq *et al*. 2017).

5.3.3 Noise

Exposure of chickens to noise stress from external sources (faulty engines, aircraft, etc.) or internal sources (power generators, heavy trucks, etc.) can significantly reduce feed intake. Chickens are believed to experience stress at noise levels of 85 decibels (dB) and above. Noise stress can reduce feed intake by 12–25 percent. Loud noises such as yelling and slamming of gates also negatively affect pig feeding behaviour. The effect of noise on feed intake is mainly due to changes in neural and endocrine functions that reduce the rate of feed passage in the animal's gastrointestinal tract and affect its ability to consume more feed.

6. Feed Management for Efficient Pig and Poultry Production

6.1 Feeding different classes of pigs and poultry

6.1.1 Flush feeding

Flushing is defined as a drastic increase in feed quantity and quality before breeding a sow or gilt. Feed quantity is decreased immediately after mating to avoid excessive weight gain during pregnancy and farrowing difficulties. Flushing has numerous benefits, including the following.

- Improved nutrition increases ovulation and litter size.
- Heavier birth weight of the piglets.
- Allows sows to reserve sufficient nutrients for higher milk production, leading to heavier piglet weaning weight.
- Increases piglet weight gain and reduces weaning period.

6.1.2 Feeding gestating sows

Feed allocation during gestation is influenced by several factors, including sow body condition, breed and parity. About 2–2.5 kg of feed a day is adequate for pregnant sows in good condition. However, sows in poor body condition and those in their first parity will require more feed throughout the gestation period to provide for maternal weight gain. Feeding should be limited for gestating sows to avoid excessive fat deposition (obesity) that may pose farrowing problems. A good way of achieving this is to increase diet fibre content by including ingredients such as wheat bran, brewer's spent grain and alfalfa meal. It is good practice to reduce fibre content and increase protein, vitamin and mineral content during the last three to four weeks of pregnancy to provide for foetal growth, successful farrowing and subsequent milk production.

Table 6.1	Influence of feeding during pregnancy on farrowing performance				
Daily feed intake (kg)	**Piglets born alive**	**Piglets born dead**	**Piglet weight (kg)**	**Litter weight (kg)**	**Farrowing duration (hr.)**
1.7	11.8	1.3	1.2	15.3	6
3.7	10.1	1.9	1.2	14.2	7

Source: Author's adaptation from Serres (1999)

Table 6.2	Feed intake influence on sow milk production and body-weight loss			
Daily feed intake (kg)	4.4	5.1	5.9	6.8
Milk production (kg/day)	6.0	6.1	6.6	7.0
Body weight loss (kg)	33.0	18.0	12.0	6.0

Source: Author's adaptation from Serres (1999)

6.1.3 Feeding lactating sows

Sows need more feed during lactation than in any other phase of the production cycle. A sow should eat enough feed to produce sufficient milk for its piglets. In optimum environmental conditions, litter size has the most significant influence on sow feed intake. As a rule of thumb, a lactating sow should be fed 2 kg feed/day plus 0.5 kg feed/piglet/day. For a sow raising 10 piglets, this will amount to 2 kg + (0.5 kg × 10) = 7 kg of feed per day. This quantity can be distributed in two or three meals per day. Choice feeding (see page 37) is good practice during lactation as it helps a sow meet her needs to minimize body weight loss and maximize piglet growth.

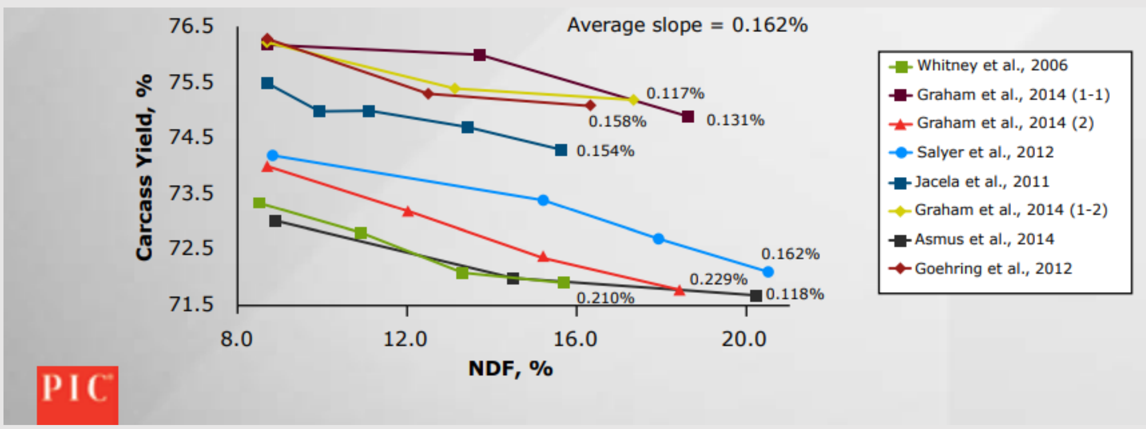
6.1.4 Feeding weaner, grower and finisher pigs

A weaner diet must be adapted to digestive capacity. The diet is high in nutrients (about 16-20 percent crude protein) and must be palatable, fresh and digestible. Feed troughs must be checked regularly for soiling to avoid sudden digestive disturbances.

The grower phase is the period starting from 8–10 weeks to 14–16 weeks, characterised by rapid lean growth. The grower diet, which is high in energy, protein and essential amino acids, is normally fed freely to pigs weighing about 20 kg up to 45–60 kg live weight.

Finisher diets are fed to animals from 45–60 kg at a scale that will optimize growth rate, feed efficiency and carcass quality. Finishing (fattening) pigs should be fed as much and as often as necessary, with adequate feeding space provided to prevent competition for feed. As illustrated above, the change from grower to finisher feed should be made gradually over a period of one week. The degree of fattening can be assessed based on carcass quality or feed conversion ratio (FCR). On good quality diets, pigs should be finished when the FCR is approximately 3.5. Excess oilseed cakes (soybean cake, canola cake, etc.) in the diet can result in soft pork. Therefore, they should be withdrawn or drastically reduced toward the end of finishing. While fibrous ingredients may reduce feed cost, high fibre levels in the diet have been found to reduce carcass yield. It is recommended that diets contain less than 9 percent neutral detergent fibre (NDF) when animals are approximately two weeks before market age (Coble *et al*. 2015). The effect of dietary NDF on pig carcass yield from different author studies is shown in Figure 6.1 below.

Figure 6.1 **Effect of increasing NDF on carcass yield of finishing pigs**



Source: Coble *et al.* (2015)

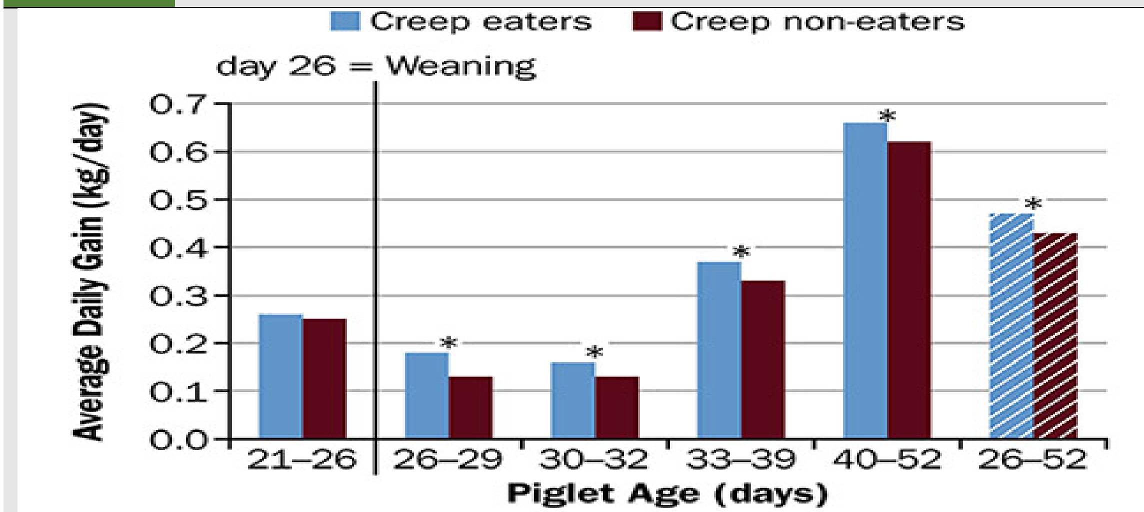
6.1.5 Creep feeding

Creep feeding is a transition strategy aimed at introducing piglets of approximately 10 days of age to solid feed to prepare their digestive system for weaning. Creep feed is provided in an area accessible to the piglets only (creep area). The creep diet is free from ANFs, palatable, readily digestible and contains no less than 16 MJ DE/kg and 20 percent crude protein. If creep feeding is practiced, the change to weaner feed should be completed over one week. The benefits of creep feeding are many and include the following.

- Reduces weaning stress as the piglets get used to solid feed at an early age.
- Enzymes responsible for digestion of starch, sugar and non-milk proteins are low in piglet digestive systems in early life. Creep feeding helps the piglet gut adapt to these nutrients.

- Enhances piglet growth through supplemental nutrient provision and reduces weaning age.
- Reduced weaning age means more piglets per sow per year.
- Creep feeding keeps a sow in better nutritional condition and prolongs her reproductive life.

Figure 6.2 **Effect of creep feeding on pre- and post-weaning average daily gain of weaner pigs**



Source: Shea *et al.* (2013)

Table 6.3 **Summary of pig feeds and nutrient content**

Feed type	Class of pig	Protein content (%)	Digestible energy (MJ/kg)	Lysine (%)	Calcium (%)	Phosphorus (%)	NaCl
Creep	Piglet-weaning (8–10 kg)	20–24	13.0	0.8	0.85	0.65	0.30
Weaner	10–25 kg	16–20	13.0	0.7	0.85	0.65	0.30
Grower	25–50 kg	14–16	14.0	0.68	0.98	0.70	0.32
Finisher	50–100 kg	12–14	10.0	0.66	0.78	0.59	0.30
Boar breeder	Boars	13–16		0.66	0.85	0.40	0.30

Table 6.3 (Cont)

Feed type	Class of pig	Protein content (%)	Digestible energy (MJ/kg)	Lysine (%)	Calcium (%)	Phosphorus (%)	NaCl
Sow breeder	Guilts and sows	13	13	0.45	0.85	0.65	0.3
Lactation	Sows: farrowing–piglet weaning	13–16	13	0.7	0.85	0.65	0.3

Source: Author's adaptation from Cromwell *et al* (1993), ©McDonald *et al* (2011)

6.1.6 Feeding meat–type chickens (broilers)

Meat-type birds or broilers are normally fed in two or three phases as follows:

- Phase 1: Broiler starter (22% crude protein) - first two weeks of age.
- Phase 2: Broiler grower (20% crude protein) - weeks three and four.
- Phase 3: Broiler finisher (19% crude protein) - weeks five and six.

6.1.7 Feeding egg-type chickens (layers)

Egg-type birds may be fed in three to five phases as follows.

- Phase 1: Chick starter feed (20% crude protein) fed from 1–6 weeks.
- Phase 2: Pullet grower feed (17.5% crude protein) fed from 6–12 weeks.
- Phase 3: Pullet developer feed (15.5% crude protein) fed from 12–15 weeks.
- Phase 4: Pre-lay feed (16.5% crude protein) fed from 15 weeks-egg laying.
- Phase 5: Layer feed (17.5% crude protein) fed during egg production.

While Phase 1 is common to all farms, in broilers some farmers may combine phases 2 and 3 and in layers combine phases 4 and 5. Due to the high heat of protein digestion, feeding low to moderate protein diets is desirable in the tropics. Currently, there are no scientific studies on nutrient requirements for local chicken breeds. The majority of studies on feeding local chickens use requirements for light layer breeds, such as the Leghorn.

Table 6.4	Summary of broiler feed and nutrient content							
Growth phase	**Age (days)**	**Crude protein (%)**	**ME (MJ/kg)**	**Lysine (%)**	**Methionine (%)**	**Calcium (%)**	**Available phosphorus (%)**	**NaCl**
Starter	1-10	21–22	12.70	1.32	0.50	0.90	0.45	0.3
Grower	11–22	19–20	13.0	1.19	0.48	0.84	0.42	0.3
Finisher	23–42	18–19	13.3	1.05	0.43	0.76	0.38	0.3

Source: Author's adaptation from Cobb500 Broiler (2002)

Table 6.5	Summary of layer feed types and nutrient content							
Growth phase	**Age (weeks)**	**Crude protein (%)**	**ME (MJ/kg)**	**Lysine (%)**	**Methionine (%)**	**Calcium (%)**	**Available phosphorus (%)**	**NaCl**
Chick starter	0–6	18–20	12–12.4	1–1.2	0.45–0.54	0.95–1.0	0.48–0.50	0.3
Pullet grower	6–18	16–16.5	11.5	0.78–0.80	0.35–0.38	0.9–2.20	0.42–0.45	0.3
Layer	>18	16.5–17.0	11.7	0.8–0.85	0.38–0.41	4.0	0.33–0.40	0.3

Source: Author's adaptation from *Shaver 579 Layer Management Guide.* 2005.

6.2 Feeder management

Good feeder management is key to efficient pig and poultry production. Poorly managed feeders will increase feed wastage and reduce pig and poultry performance. Feed wastage from a feeder alone can be up to 5 percent or more. Feeder design, position and available space are all important management practices.

6.2.1 Feeder position

Feeder position in the house affects access to feed and animal performance.

- Placing feeders in corners will not only reduce feeding space but also encourage contamination, especially in pigs, which use cold corners as a toilet.
- Pigs and poultry always like to drink as they feed. If the feeders are placed far away from the drinkers, the animals will waste energy by walking to drink. Feeders should not be more than two metres away from the water source. However, placing feeders too close to drinkers may reduce feeding space and encourage water spillage on the feed, as well as mould development, especially when wet feed is in the feeder for a long period.

- Feeder height should be adjusted according to animal growth stage. Pigs and poultry will jump for feed when feeders are too high, leading to feed wastage and increased body heat production.

6.2.2 Trough space and feed distribution

Even when feed is balanced in all required nutrients and supplied in sufficient quantities, pigs and poultry need sufficient space around the trough to achieve maximum performance. Adequate feeder space will reduce competition for feed and promote good animal performance (growth, egg production). Inadequate feeder space encourages fighting, feather pecking and cannibalism and feed wastage, and reduces flock uniformity and productivity. Stronger animals will consume more feed than necessary while weaker ones will feed less. Neither overfeeding nor underfeeding is desirable. Troughs should not be more than two-thirds filled as overfilling can lead to feed wastage. Minimum space recommendations (floor and trough) for pigs and poultry are summarized in the Tables below.

Table 6.6 Pig trough space requirements

Pig class	Feeding space (m/pig)
Weaner	0.15
Grower	0.25
Finisher	0.30
Breeder	0.45

Source: Author's adaptation from Queensland Government Department of Agriculture and Fisheries (2023)

Table 6.7 Egg-type poultry trough space requirements

Bird age (weeks)	Feeding space (cm/bird)
0–4	1.5
5–8	3
9–20	6
Adult birds >20	12

Source: Author's adaptation from Smith (2001)

Table 6.8	Feeding space (cm/bird)
Bird age (days)	**Feeding space (cm/bird)**
Up to 18	3
18–42	7

Source : Broiler management (n.d)

Space calculation exercises

Exercise 1

Using Table 6.7, how many feeders measuring 1 m circumference would be required for 10 000 laying hens?

Answer

- Each layer requires 12 cm feeder space; thus 10 000 layers will require 12 cm × 10 000 birds = 120 000 cm space.
- Each feeder has a circumference of 1 m or 100 cm.
- Number of feeders = 120 000 cm ÷ 100 cm = **1 200 feeders**.

Exercise 2

How many broilers (30-day old) can comfortably feed from 100 feeders measuring 80 cm circumference each?

Answer

- Total space around the feeders = 100 feeders × 80 cm = 8 000 cm.
- From Table 6.8, a broiler aged 30 days requires 7 cm feeding space; thus, the number of broilers will be 8 000 cm ÷ 7 cm = **1 143 broilers**

6.3 Feed storage

Appropriate feed storage is required for ensuring adequate nutrition. Nutrients such as carbohydrates, fats and vitamins are destroyed during storage. During extended storage under poor conditions, carbohydrates are converted to CO_2 and H_2O. Fat oxidation during storage makes the feed unpalatable and renders the fat-soluble vitamins inactive. Many vitamins, including A and E, are also lost when feeds are stored under hot conditions. Poorly stored feeds are liable to promote mould development, causing illness and poor animal performance. Rodents will not only result in feed waste but are also carriers of many pathogenic organisms than can cause serious infections in pigs and poultry. Proper packaging helps prevent contamination and ensures that the feed remains safe and hygienic for consumption.

- Always supply feed that is as fresh as possible to minimise nutrient loss, risk of illness, and to save storage space.

- Do not store pig and poultry feeds for more than one month. While it is a common practice in the region to store feed in containers for longer periods, this leads to reduced feed quality and animal performance. If a farmer is to store feed for longer periods, the storage room must have good ventilation and temperature (between 10 and 25C). Temperatures above 25C will increase moisture content, which encourages mould growth and leads to nutrient loss. Adequate ventilation in the storage room will prevent moisture build-up and increase storage period length.
- Store feed in clean, dry, rodent-proof and well-ventilated facilities. Rodents do not only waste feed but may also carry disease pathogens.
- Make sure feeders are cleaned every week to avoid caking and mould development.

Feed stored in a plastic container with lid at the University of South Pacific Samoa Campus ©Siaka Diarra

For proper feed packaging, note the following.

- Use high-quality materials – The packaging material should be sturdy, durable and able to withstand storage and transportation conditions. High-quality materials also help to prevent contamination and feed spoilage.
- Ensure proper sealing – The packaging should be tightly sealed to prevent moisture and pests from getting in. This can be achieved using heat sealing, adhesive sealing, or other sealing methods.

- Include clear labelling – The packaging should be clearly labelled with product name, brand name, weight, feeding instructions, ingredients, and nutritional information. This information should be easy to read and understand.
- Provide storage instructions – The packaging should include instructions for proper storage to ensure that the feed remains fresh and safe for consumption. This may include recommendations for temperature, humidity and exposure to light.
- Use appropriate packaging sizes – The packaging size should be appropriate for the quantity of feed being sold, with larger bags or containers used for bulk purchases and smaller ones for smaller quantities. This helps to reduce waste and makes it easier for customers to handle and store the feed.
- Monitor quality control – Regular checks should be carried out on feed quality and packaging to ensure that it meets the required standards. This can help to identify and correct any issues before they lead to contamination or spoilage.

6.4 Split sex feeding

Males and females differ in feed intake and potential to convert their feed into products. As pigs grow older, protein deposition and feed efficiency differ between females and males. As female pigs need less energy for basic body functions, they may deposit more fat than males at a similar feed intake.

Split-sex feeding, or feeding males and females separately, is a practice aimed at matching diet specifications to the nutritional requirements of males and females. It also improves feed efficiency, especially in pigs. Split sex feeding has the following benefits.

- Reduces aggressive behaviour and fighting.
- Allows uniform growth.
- Improves growth rate, feed efficiency, and carcass quality.

A major disadvantage of split-sex feeding is the additional cost of partitioning pens for males and females.

6.5 Choice feeding

It is a common practice to mix different ingredients in different proportions to balance nutrient content for pigs and poultry. This practice does not consider that pigs and poultry may prefer certain feed ingredients and may avoid others. When given the choice, pigs and poultry will select ingredients that balance their requirements at minimal cost. Choice feeding has several advantages, including the following.

- Reduces processing cost and labour (grinding, pelleting, mixing).
- Avoids excessive consumption of expensive feed ingredients.
- Removes the need for feed analysis.

- Stimulates digestive organ development and feed utilization.

These advantages have led choice feeding to receive great interest on small to medium holder farms. The results of a choice feeding trial in laying hens are presented in Table 6.9 below.

Table 6.9	**Self-selection of dietary ingredients by chickens**						
Ingredients offered	**Carbohydrates**			**Animal proteins**			**Mineral source**
	Yellow Maize	Oatmeal	Wheat bran	Fishmeal	Bone meal	Dried skim milk	Oyster shell
Ingredient intake (%)	52.8	8.9	21.3	11.4	2.9	2.1	0.6
Total intake per category (%)	83.0			16.4			0.6
Nutrient content of selected diet	Crude protein (17.9%), Calcium (1.3%), Phosphorus (1.1%), Metabolizable energy (11.42 MJ/kg)						

Source: Author's adaptation from Henuk et al (2000)

7. Feed processing for maximum inclusion of locally available ingredients in monogastric Diets

Antinutritional factors, bulk density and nutrient imbalances are the major constraints to maximum inclusion of locally available ingredients in pig and poultry diets. These constraints can be overcome through adequate processing and additionally improve local ingredient utilization. The objectives of feed processing are many and include the following.

- Detoxify the feed – The concentration of toxic factors such as cyanide in cassava root and leaf, oxalate in giant taro, trypsin inhibitor activity in soybean, etc. can be reduced through appropriate processing.

- Improve the keeping quality and reduce storage space – Most locally available feed ingredients are characterised by high moisture content and bulk density. Bulky ingredients are difficult to store and require more storage space. Stored feeds with high moisture are prone to contamination, especially from moulds and salmonella. Both moisture content and bulk density can be reduced through processing.

- Improve palatability – Feed processing improves animal feed intake.

- Improve nutrient content and availability – Feeds high in moisture have low dry matter (DM) and nutrient contents. Processing such as drying increases DM and nutrient content. Most feed nutrients are present in complex forms that are not available to monogastric animals (pigs and poultry). Appropriate processing will break the complex structures and in turn increase nutrient availability.

There are several methods of feed processing, each having its merits and drawbacks. This section will discuss selected processing methods for maximum utilization of local ingredients by monogastric animals.

7.1 Sun Drying

Sun drying is a common feed processing method that has several advantages, including:

- Reduces bulkiness and saves storage space.
- Reduces the concentration of some heat labile ANFs, e. g. cyanide in cassava root and leaf, that improves nutritive value.
- Makes further processing easier.

High labour requirement and constant heavy rains, especially in PICs, are major constraints to sun-drying.

Cleaning, chopping and sun-drying cassava root for poultry feeding at the University of South Pacific, Samoa Campus ©Siaka Diarra

7.2 Soaking

Soaking is a common processing method in the feed industry. The duration of soaking varies from one ingredient to another and ANF concentration. The benefits of soaking include:

- Reduction of water soluble ANFs below toxic levels.
- Improves palatability.
- Improves feed nutritive value.
- Increases shelf life
- Ensures year-round feed availability.

The major drawbacks of this method are:

- Possible loss of water-soluble nutrients.
- Drying losses that can sometimes be high.
- Space requirements for drying and storage.
- Risk of spoilage during drying.
- Soaking requires a lot of water and energy.

7.3 Grinding/chopping

Chopping or grinding is a processing method aimed at reducing feed particle size. Smaller particles increase the contact surface area with digestive juices and improves digestibility. Grinding or chopping allows a homogenous mix and reduces feed wastage through ingredient selection. Grinding is also the starting point for further processing such as pellet and crumble production. Animals fed smaller particles save energy that would have been spent on digestion. Finely ground feed, however, transits through the digestion system too fast and escapes digestive juices and thus goes undigested.

Table 7.1 Influence of feed particle size (mm) on feed intake (g) of broilers from 21 to 39 days

Particle size (mm)	Mash	Pellet
0.48	2.0	2.47
0.77	2.27	2.48
0.90	2.37	2.41

Source: Author's adaptation from Leclercq, B. (1998) in Hubbard Technical Bulletin (2005)

7.4 Peeling

Most root and tuber antinutritional factors (ANFs) are concentrated in the peel. Removing the peel reduces ANFs and improves the feed's palatability. However, because many nutrients are also found in the peel or outer layer, peeling can lower the nutritive value of the feed. This loss can be compensated by adding other nutrient sources. Peels should not be discarded, as they can be processed and used to create extra income. They can be dried and ground for use as livestock feed ingredients, composted for organic fertilizer, or supplied to industries that produce biogas or process agricultural by-products. Proper utilization of peels in this way can help reduce overall livestock feeding costs.

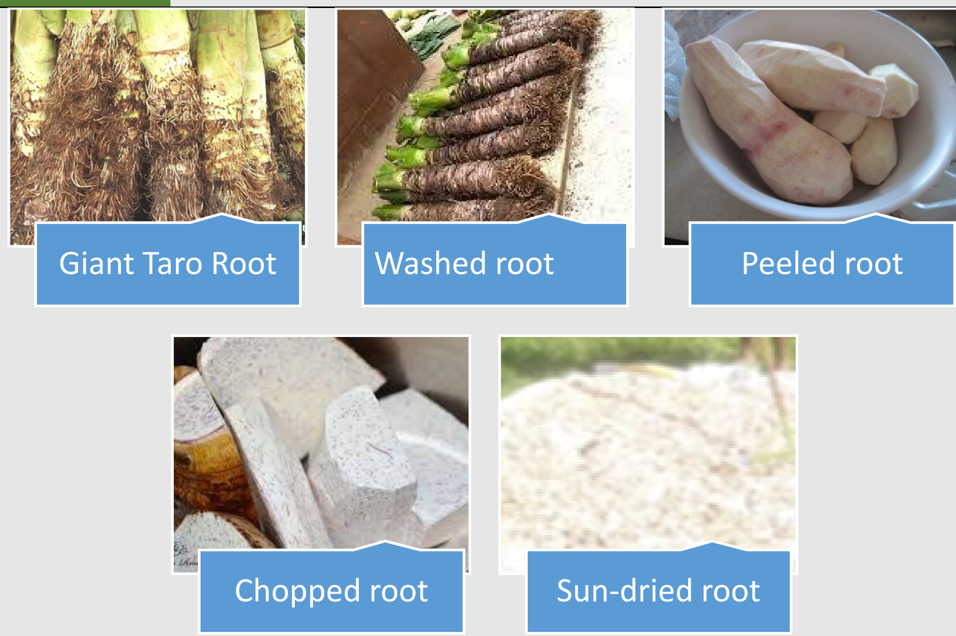
Figure 7.1 Steps for processing cassava peel into animal feed

Source: ILRI (2021)

Coarse and ground cassava peel waste used for animal feed © ILRI/I. Okike

Stored cassava peel meal for livestock feeding © ILRI

Figure 7.2 **Processing giant taro for poultry feeding at the University of South Pacific farm, Samoa**



Source: Diarra, Siaka S. (2018)

7.5 Pelleting

In pelleting, the feed is pressed through small holes (dies) using heat, moisture, and pressure. Pelleting destroys ANFs, improves feed digestibility, prevents nutrient selection, and reduces storage space. Major concerns regarding pelleting include possible destruction of heat-labile nutrients, and the cost. In addition, it takes less time to consume pellets compared to mash, which may encourage pecking in birds due to idleness.

7.6 Boiling

Boiling is the application of moist heat to feed. The feed is submerged in water to allow even heat distribution. Depending on feed type, feed ingredients may be added to already boiling water or cold water and boiled together. The latter is commonly used in blood meal processing. Boiling destroys anti-nutritional factors and improves palatability and digestibility. The main disadvantages of boiling include loss of water soluble and heat-labile nutrients, drying losses and risk of spoilage.

7.7 Roasting

Roasting is a method of cooking using dry heat. It is usually applied to grains and pulses. Roasting destroys antinutritional factors and improves digestibility. However, the heat from roasting may not penetrate deeply into the seed or grain. This means than roasting is most effective on ANFs that are in higher concentration in the outer coat of seeds and pulses.

7.8 Fermentation/ensiling

Fermentation or ensiling reduces ANF content and improves feed ingredient digestibility in pigs and poultry. The effect of ensiling, or fermentation, on cassava products from selected studies is summarized in Table 7.2 below.

Table 7.2 Effects of ensiling on HCN content and digestibility of cassava products

Ensiled cassava product	Comments	Sources
Cassava root	HCN content reduced by 81%	Nguyen 2012
Leaves	HCN content reduced by 62%	Phuc *et al*. (2000)
	68% HCN reduction after 2 months of ensiling.	Van Man and Wiktorsson (2022)
	76% HCN reduction after 4 months of ensiling	
	Improved crude protein digestibility	Lindberg (2007)
	Ensiling with *Aspergillus oxyzae* improved crude protein digestibility	Khempaka *et al*. (2014)

Source: Author's analysis

7.9 Feed safety

After adequate processing, feed ingredients and compound feeds need to be stored appropriately for maximum safety. Poor storage can result in several negative feed changes that reduce its quality and quantity. The nutritional quality of stored feed is known to diminish daily (Yegani *et al*. 2002). Storage conditions have the greatest influence on feed quality. Several factors that include fungi, bacteria, rodents, relative humidity, and enzyme activities may cause feed spoilage or denaturing (Reddy *et al*. 2001; Waheed *et al*. 2004; Maciorowski *et al*., 2006). According to Waheed *et al*. (2004), high light intensity, high relative humidity and high storage temperature accelerate feed spoilage. Since these extreme weather conditions are present in Pacific region for most of the year, it is important to pay utmost attention to feed storage conditions to maintain feed quality and minimize losses.

8. Concluding Notes

- High feed cost is a major factor limiting the growth of the pig and poultry industry globally, and Pacific Island countries in particular.
- Locally available or non-traditional ingredients can be used to reduce feed costs, thereby increasing revenue and promoting better environmental health by reducing waste and the pressure on conventional feed resources.
- High fibre content and the presence of antinutritional factors affect efficient utilization of non-traditional ingredients in the diet.
- Appropriate processing and correct diet formulation will allow maximum utilization of non-traditional feed ingredients and reduce pig and poultry production cost.
- Due to the relatively low nutrient density and high fibre content of locally available ingredients compared to traditional ones, it is difficult to formulate complete pig and poultry diets based on local ingredients only.
- Alternative ingredients can, however, be included in the diet to replace some traditional ingredients and reduce cost.
- Cassava root meal is the most common alternative energy source, while copra meal, leaf meals, abattoir byproducts, and insect meal are readily available protein sources for both pigs and poultry feeding in the region.
- Inclusion of alternative ingredients depends on several factors, including species, age and class of animal, and extent of feed processing.

9. Appendices: Sample Pig and Poultry Diets Containing Local Ingredients

Appendix 1 Comparison of pullet grower diet composition based on local resources and performance results with a commercial pullet grower diet at the USP farm - Samoa

Ingredients (%)	**Diet**	
Cassava root-leaf meal (4: 1)	69.42	
Vegetable oil	3.0	
Copra meal	15.0	
Fish meal	7.5	
Limestone flour	4.0	
Lysine HCl	0.3	
DL-Methionine	0.2	
Mineral vitamin premix	0.25	
Enzyme	0.03	
NaCl	0.3	
Analysis		
Crude protein	15.1	
ME (MJ/kg)	2851.1	
Pullet performance	**Local formulation**	**Commercial feed**
Feed cost rearing (WST$/pullet)	7.1	13.7
Daily feed intake (g/bird)	88.5	100.9
Weight at 18 weeks (g)	1551.7	1 759.5*
Age at first egg (days)	137	130
Weight of first egg (g)	48.2	45.7

* Overweight for age, likely due to overconsumption | Source: Diarra (2015)

Appendix 2	**Comparative performance of broilers fed a controlled diet and cassava peel meal (CPM) plus tallow and enzyme**	
Ingredients (%)	**Controlled diet**	**CPM + tallow + enzyme**
Maize	38.5	23.1
Wheat	20.0	19.0
Tallow	0.0	2.5
CPM	0.0	15.4
Pea meal	20.0	17.0
Fish meal	5.0	5.7
Copra meal	5.7	5.7
Meat and bone meal	7.9	8.5
Enzyme	0.0	0.35
Premix	0.25	0.25
Lysine HCl	0.2	0.2
DL-methionine	0.1	0.1
Salt	0.3	0.3
Sand	2.0	2.0
Analysis		
Crude protein	20.0	20.0
Metabolizable energy	12.9	12.8
Broiler performance		
Daily feed intake (g/bird)	177	190
Daily weight gain	98	108
Feed conversion ratio	1.81	1.76

Source: Author's adaptation from Dayal *et al* (2018).

Appendix 3	Maize or cassava meal-based diets for broiler finisher	
Ingredients (kg)	**Control diet**	**Cassava meal-based diet**
Maize	52.5	0.0
Sun-dried cassava meal	0.0	48.0
Coconut oil	5.0	6.0
Copra meal	10.0	10.0
Meat and bone meal	17.0	20.5
Fish meal	15.0	15.0
Salt	0.3	0.3
Premix	0.2	0.2
Composition		
Crude protein (%)	22.8	22.7
ME (MJ/kg)	13.4	13.4
Broiler performance		
Final weight (kg)	1.9	1.7
Feed intake (kg)	4.0	3.8
Feed conversion ratio	2.1	2.2
Feed cost per broiler (WST$)	3.41	2.29

Source: Author's analysis

Appendix 4	Cassava meal and cassava peel meal-based diets for finishing pigs	
Ingredient (%)	**Control diet**	**Cassava meal-based diets**
Yellow maize	53.0	8.0
Cassava root meal	0.0	30.0
Cassava peel meal	0.0	20.0
Groundnut cake	10.0	11.0
Fish meal	3.0	4.0
Brewers' dried grain	2.0	16.0
Rice bran	27.0	6.0
Composition		
Crude protein	14.3	14.1
Digestible energy (MJ/kg)	30.0	21.6
Performance of the pigs		
Gain (kg/day)	0.48	0.40
Feed intake (kg/day)	1.64	1.59

Source: Author's adaptation from Sonaiya and Omole (1983)

Appendix 5	Performance of finishing pigs fed controlled and diets containing cassava root, cassava leaf and Trichanthera leaf meals	
Ingredient (%)	**Controlled diet**	**Cassava meal-based diets**
Yellow maize	49.64	5.47
Sorghum	20.0	0.0
Sugar cane molasses	4.0	4.5
Palm oil	3.1	9.0
Cassava root meal	0.0	40.0
Soybean meal	18.65	13.4
Fish meal	4.2	6.1
Cassava leaf meal	0.0	10.0

Appendix 5 (cont.)

Ingredient (%)	**Controlled diet**	**Cassava meal-based diets**
Trichanthera foliage meal	0.0	10.0
$CaCO_3$	0.0	0.25
NaCl	0.15	0.15
Lysine	0.0	0.2
Methionine	0.0	0.2
Analysis		
Crude protein	17.59	18.1
GE (KJ/DM)	17.15	19.25
Pig performance		
Daily gain (g)	662	688
DM intake (kg/day)	2.25	2.50
DM conversion	3.71	3.62
Carcass yield	77.4	77.9

Source: Author's adaptation from Jiménez *et al* (2005)

Appendix 6	Cassava root and leaf meal-based diets for growing pigs at USP Farm, Samoa	
Ingredient (%)	**Controlled diet**	**Cassava meal-based diets**
Maize	25.5	23.4
Cassava root meal	31.9	35.0
Wheat bran	19.1	11.6
Fish meal	7.1	6.8
Soybean meal	14.1	13.4
Cassava leaf meal	0.0	7.4
NaCl	0.6	0.6
Coral sand	1.0	1.0
Lysine	0.3	0.4
Methionine	0.15	0.18
Analysis		
Crude protein	16	16
ME (MJ/kg)	14.2	14.1
Pig performance		
Daily gain (kg/pig)	0.28	0.35
Daily intake (kg/pig)	1.0	1.2
Feed cost of gain (US$)	2.2	1.5

Source: Author's adaptation from Diarra *et al* (2017)

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